Survivability/Vulnerability Information Analysis Center

SURVIAC Bulletin

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SURVIAC is a U.S. Department of Defense Information Analysis Center (IAC) sponsored by the Defense Technical Information Center (DTIC).

# Developing unclassified hit and kill probabilities for JCATS

Operate any commercial war game or simulation, and you will see the good guys and bad guys shooting at each other and/or at each other's vehicles. Some shots hit their targets, some miss. Some shots damage their targets; some kill their targets outright…catastrophically. Yet, the computer code used to generate hits and misses is unclassified. Can one generate probabilities of a hit (Ph) and probabilities of a kill given a hit (Pk/h) for military simulations that are also unclassified? The Survivability/ Vulnerability Information Analysis Center (SURVIAC) was tasked to produce these two unclassified probability databases for selected threat-target pairings in the Joint Combat and Tactical Simulation (JCATS). This article describes the approach selected by SURVIAC to accomplish the task, by describing the JCATS model, the crucial part which open-source literature plays in the task, and our use of parametric estimation.

## Joint Combat and Tactical Simulation

JCATS was produced by the University of California, Lawrence Livermore Laboratory, and evolved from a merger of the Joint Tactical Simulation (JTS) and the Joint Conflict Model (JCM). JCATS is designed to run in a distributed environment on personal computers running Red Hat Linux GNOME. It is a complex, data-driven model, and is multi-sided, interactive, entity-level conflict simulation used as a tool for training, analysis, planning and mission rehearsal. Because of the distributed environment in which JCATS operates, as well as the fact that in some applications, foreign nationals are participating, the client generated the requirement that the Ph and Pk/h data must be unclassified.

The Probability of Hit (Ph) is used to define the ability of a specific weapon and munition to hit a specific target. It presumes that target detection has occurred. The Ph curve defines five parameters to describe the relationship between the threat and the target. The range, the distance between the shooter and the target, is given in meters. The other four parameters describe the movement of the shooter (stationary (S) or moving (M)), the movement of the target (stationary (S) or moving (M)), the target's defilade status (fully exposed (E) or in defilade (D)), and the munition's incident angle (head-on (H) or other-than head-on, called flank (F)). If a target is in defilade, it is positioned in a fighting position, and therefore only partially visible to the shooter; for example, typically only the head and shoulders of an individual or the turret of a tank are visible when in defilade. The size of target is not one of the parameters; it is accommodated within the Ph calculations.

The Ph curve will display a probability number (x100) for each condition represented by a combination of the four parameters listed above, in the order listed. Each condition will have four letters, in the order listed. For example, the combination SMEH represents the threat-target rela-

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# Report Documentation Page

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# In This Issue



## Send us your feedback!

We would like to hear from you. Have we helped you in some way? Would you like to author an article for the SURVIAC Bulletin? What issues would you like to see discussed in upcoming bulletins? Modeling & Simulation? Homeland Defense / Homeland Security? Space Survivability Issues? Unmanned Aerial Systems? Please e-mail your comments to surviac@bah.com.

SURVIAC now offers our Dynamic Events Calendar straight to your inbox the first of every month. To sign up to receive your copy, please contact Linda Ryan, (937) 255-3828 x208 or E-mail ryan_linda@bah.com.

## Threat Effects in Aircraft Combat Survivability DVD

The *Threat Effects in Aircraft Combat Survivability* documentary video project was funded by the Joint Aircraft Survivability Program Office (JASPO). This project substantially updates the material presented in the original "*Threat Effects in Aircraft Combat Survivability*", released in 1986. This documentary uniquely presents the primary threat weapons to aircraft and the ballistic response or "effect" of an aircraft when hit by a threat. It contains combat and gun-camera footage and both lethality and survivability test analysis video, all of which are combined and edited to demonstrate the cause and effect relationship between threats and their effect on an aircraft on the battlefield. The benefits gained from using technologies in vulnerability reduction will further increase the viewers' interest in, knowledge of, and appreciation for the survivability discipline.

The response to the "Threat Effects in Aircraft Combat Survivability" DVD documentary developed by Robert E. Ball, Jr. has been overwhelming, swamping the JASPO with requests. As a result, JASPO has arranged for DVD distribution through SURVIAC. Please send all future requests to SURVIAC. The cost of this DVD is $50.00 (free to govt.)

To request a copy of the Threat Effects in Aircraft Combat Survivability DVD, please fill out the request form on the SURVIAC website at: http://www.bahdayton.com/surviac/inquiry.aspx or contact Mr. A.J. Brown at SURVIAC (937) 255-3828 ext. 284, Email: brown_aj@bah.com

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tionship where the shooter is stationary, the target is moving, fully exposed, and is facing or moving head-on toward the shooter. SSDF means the shooter and target are both stationary, with the target in defilade facing away from the shooter. For personnel or infantry, JCATS only uses the Flank relationship, never Head-on. Therefore, for simplicity in the tables, the Flank and Head-on Ph values are the same in columns with the first 3 designators. i.e. SSDF/SSDH, where the shooter and target movement and target's presentation are the same (see Ph table below.)

The Probability of a Kill Given a Hit (Pk/h) is used to define the ability of a specific weapon and munition to damage a target. It presumes that the munition has impacted the target. JCATS uses four different levels of kill: mobility (MoBPk), firepower (FpPk), mobility and firepower (MoFPk), and catastrophic (KkPk). A mobility kill is defined as the loss of a target's ability to maneuver; however, the target still possesses the ability to fire its weapons, such as a tank with its tracks disabled. A firepower kill is defined as the loss of a target's ability to fire its weapons, such as a tank with gun tube damage. Mobility and firepower kill is defined as a situation where a target is not killed, but is suppressed. Catastrophic kill is defined as the destruction of a system's ability to perform any combatant function or is dead.

A major problem facing any simulation is the accuracy of the data sets used in the Ph and Pk/h curves. A simulation's effectiveness is only as good as the data used to populate the requisite input data curves. Therefore, the more closely the Ph and Pk/h data resembles real life, the more effective will be the training or mission rehearsal derived from running a scenario. Unfortunately, many Ph and Pk/h curves are derived from actual live fire tests, manufacturer's literature, and other sources that are inherently classified. When classified data sources are used, the database is also classified. Also, depending upon the target and/or threat munition, simply the use of either will result in a classified database. And finally, often when a specific threat is paired with a specific target, and detailed damage is recorded, the database becomes classified.

The unclassified data that could be collected on the threats and the targets were used as inputs to develop the Ph and Pk/h estimates. Pk/h data is generated using unclassified three-view drawings and inboard profiles of the targets, which illustrate the size and location of the internal components of the target systems as well as the target's overall presented areas. When possible, unclassified vulnerability data for the critical components was used. When this data was not available, the component Pk/h data was generated using unclassified methodologies. The component Pk/h values are then multiplied to the presented area of the component to determine the individual component vulnerable area (Av) (Equation 1). The summation of the critical components' vulnerable areas is then divided by the total presented area of the target and the result is the total target Pk/h value (Equation 2).

$$ComponentAv = ComponentAp * ComponentPk/h \quad (1)$$

$$TargetPk/h = \varsigma ComponentAv \div TargetAP \quad (2)$$

The fundamental issue for this task is that SURVIAC must find that balance between adequate, useable Ph and Pk/h data curves and the creation of an unclassified product.

A typical Ph curve representing a 9mm versus a dismounted infantry would appear as follows:

| RANGE | SSDF | SSDH | SSEF | SSEH | SMDF | SMDH | SMDH | SMEH | MSDF | MSDH | MSEF | MSEH | MMDF | MMDH | MMEF | MMEH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 95 | 95 | 99 | 99 | 85 | 85 | 89 | 89 | 75 | 75 | 79 | 79 | 65 | 65 | 69 | 69 |
| 10 | 87 | 87 | 87 | 87 | 87 | 87 | 77 | 77 | 77 | 77 | 67 | 67 | 67 | 67 | 57 | 57 |
| 20 | 50 | 50 | 60 | 60 | 40 | 40 | 50 | 50 | 30 | 30 | 40 | 40 | 20 | 20 | 30 | 30 |
| 30 | 30 | 30 | 45 | 45 | 20 | 20 | 35 | 35 | 10 | 10 | 25 | 25 | 5 | 5 | 15 | 15 |
| 40 | 20 | 20 | 40 | 40 | 15 | 15 | 30 | 30 | 10 | 10 | 20 | 20 | 5 | 5 | 10 | 10 |
| 50 | 10 | 10 | 35 | 35 | 9 | 9 | 25 | 25 | 5 | 5 | 15 | 15 | 1 | 1 | 5 | 0 |

A typical AK-47 7.62x39mm vs. Blue infantry (w./helmet & plate armor) would appear as follows:

| RANGE | MOBEH | MOBEF | MOBDH | MOBDF | FRPEH | FRPEF | FRPDH | FRPDF | MOFEH | MOFEF | MOFDH | MOFDF | KKEH | KKEF | KKDH | KKDF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | 35 | | 0 | | 15 | | 36 | | 0 | | 0 | | 10 | | 24 |
| 200 | | 33 | | 0 | | 14 | | 33 | | 0 | | 0 | | 10 | | 23 |
| 400 | | 30 | | 0 | | 13 | | 30 | | 0 | | 0 | | 9 | | 22 |
| 600 | | 24 | | 0 | | 11 | | 25 | | 0 | | 0 | | 8 | | 29 |
| 800 | | 19 | | 0 | | 9 | | 20 | | 0 | | 0 | | 7 | | 17 |

## Open-source Literature

The crucial, overriding element of the JCATS database support task is the development of unclassified Ph and Pk/h data. Data from which to build the required database must come from open-source literature or must be generated by unclassified simulations using unclassified input. Primary open sources used in this task include web sites, ammunition manufacturers, subject-matter experts (SMEs), and other sources that may develop as the task matures.

Two of the web sites used in this task include www.fas.org and www.globalsecurity.org. Both web sites maintain a large database of U.S. and foreign weapons, munitions, and vehicles. In some instances, they even contain generalized Ph estimates for weapons in optimum conditions. Examples of ammunitions manufacturers include Winchester, Remington, and Colt Fire Arms.

SMEs were asked to provide gross, "does-the-data-make-sense" checks. For example, in some cases, especially for small arms/automatic weapons (SA/AW), Ph data appeared to reflect relatively high probabilities. SMEs, and especially those with combat experience, observed that in many cases those numbers were likely to reflect optimum conditions, e.g., shooters on a firing range, no cross wind, etc. The SMEs recommended that the probabilities be reduced to reflect more of a combat environment with a greater degree of excitement, anxiety, movement, distractions due to smoke, explosions, enemy fire directed at the shooter, etc. A possible exception to this observation was that the hit probabilities for snipers would generally be higher than regular infantry troops because of more intensive training and weapon familiarity and the fact that, generally, snipers took the first shot from concealment and/or cover, thereby mitigating much of the distractive effects mentioned above.

## Parametric Estimate

SURVIAC selected parametric estimation, supplemented with some level of computer simulation, as the approach to solve this issue. The vast majority of data held within SURVIAC's resources, with respect to combat and test data, is either classified or, when some of the unclassified data is combined, it becomes classified. Therefore, prudent use of open source literature became the only other avenue of unclassified Ph and Pk/h data for the JCATS application.

With time and the normal declassification procedures, combat data becomes unclassified. A significant portion of combat data generated from Korea and Southeast Asia (SEA) have been declassified. Therefore, the approach for Ph data focuses on selecting representative vehicles from that era, developing Ph data for selected, but unclassified threats, and then applying adjustment factors to that data to better represent categories of similar targets. For example, the use of a tank from the SEA era, such as the old Soviet T-54, would be used to develop Ph data for a series of selected threats, RPG-7, LAW rocket, Maverick air-to-ground missile, Hellfire air-to-ground missile, and a TOW missile. These weapons have unclassified Ph data published in open source literature.

One of the primary factors in determining a threat-target Ph is the target's presented area. The larger the target is, the higher the Ph for that threat-target pairing. Generally speaking, the farther away the target is from the threat, the lower the Ph becomes. This is not true for weapons with high-tech guidance systems, like the Hellfire and the Maverick; because these weapons seek laser designated targets, the Ph remains relatively constant, with respect to range to target. Optically-guided threats may see a slight degradation of the Ph over a longer range, and even more so if the shooter and/or target are moving. Ballistic threats, such as main tank rounds, see an even greater Ph degradation over longer ranges to target.

With respect to Pk/h data, the requesting agency desired additional simplicity in the database. Several weapon systems were placed into one of two categories, under-matched and over-matched, depending on the target it was paired against. An under-matched case would occur when the threat weapon could hit a target, but would virtually never inflict noticeable damage against that target.

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An example of an under-matched pairing might be any of the 5.56mm dismounted weapons (M-16A2, M-16A4, etc.) versus any main battle tank. Conversely, an over-matched case would occur when virtually any hit by the threat weapon would produce a catastrophic kill against a target class. An example of an over-matched pairing might be the Hellfire missile versus any vehicle in the soft-skinned wheeled support vehicle target class.

## Summary

This article provides just a quick look at the approach SURVIAC is implementing to accomplish the JCATS database support task. One of the constraints for this task, presented by the Joint Warfighting Center, is that the initial Ph and Pk/h databases to be developed must be unclassified. This necessitates a rather unique approach to data gathering and development. SURVIAC's approach is to access open literature sources that can certify the data, as well as their respective sources, are unclassified. A second part of the approach is to use the concept of parametric estimation to provide some level of differentiation between families of targets to provide a useable level of distinction within JCATS. SURVIAC analysts believe this approach will provide Ph and Pk/h databases that contain an appropriate level of realism and pedigree at an unclassified level which the Joint Warfighting Center can use to continue its critical support to the warfighter for virtual training and mission rehearsal.

*Mr. Jon A. Wheeler, an associate at Booz Allen Hamilton, has supported the SURVIAC since 1994. Mr. Wheeler has been the SURVIAC lead engineer supporting the JCATS database support to the Joint Warfighting Center since 2003. Prior to Booz Allen, Jon served in the USAF as an officer in civil engineer. He received his B.S. in Civil Engineering from New Mexico State and his M.S. in Engineering Mgt from AFIT; he is a registered Professional Engineer in Ohio. Jon is the President of the Board of Directors for the Dayton Society of Professional Engineers, a voting technical committee member with ASTM International, and a member of SAME, ASCE, and AFA. Jon can be contacted at (937) 255-3828 ext. 292, E-mail: wheeler_jon@bah.com*

### Lessons Learned from Live Fire Testing CD

***Lessons Learned from Live Fire Testing: Insights Into Designing, Testing, and Operating U.S. Air, Land, and Sea Combat Systems for Improved Survivability and Lethality* CD**
**by Mr. James O'Bryon is sponsored by**
**The Director, Operational Test and Evaluation (DOT&E) and available from SURVIAC**

Categories discussed in this CD include:
- Design Insights/Shortcomings/Changes
- Safety and User Casualties
- Tactics, Training, and Doctrine
- Battle Damage Assessment and Repair (BDAR)
- Modeling and Simulation
- Test Planning, Design, Instrumentation, and Resources
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For more information on ordering this CD contact:
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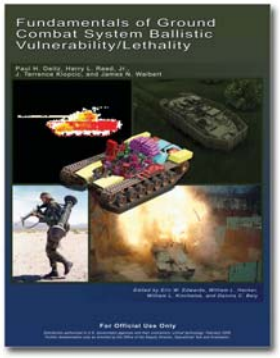
## Coming soon. . .




The Director of Operational Test and Evaluation (DOT&E), the U.S. Army Research Laboratory (ARL), the Survivability/Vulnerability Information Analysis Center (SURVIAC), and the SURVICE Engineering Company are pleased to announce the upcoming publication of the *Fundamentals of Ground Combat System Ballistic Vulnerability/Lethality.*

With contributions from more than 50 vulnerability/lethality (V/L) professionals in Government and industry, this 300-page text provides a comprehensive look at the basic history, terminology, processes, tools, and applications associated with the V/L discipline. The book is intended to serve as both a foundational textbook for new V/L analysts, testers, developers, researchers, and scientists as well as a ready-reference for those practitioners already working in the field.

*To reserve your copy, please contact A. J. Brown, SURVIAC, 937.255.3828 ext. 284 or brown_aj@bah.com.*

# Hail & Farewell: SURVIAC COR Retires

SURVIAC has lost a key person. Our long time Contract Officer's Representative (COR) Marty Lentz has retired. Marty has served as the SURVIAC COR for thirteen years. During that time he has guided SURVIAC through tremendous growth all while emphasizing increased survivability for the warfighter. Marty is being ably replaced by Ms. Peggy Wagner, 780 TS, but his many years of experience and insight will be sorely missed.

Marty Lentz receives an award from Mr. Paul Ulrich, Flight Chief, 780 TS during his retirement ceremony.

Marty entered USAF civil service in January 1974. His career spans 34 years of successfully exploiting physical sciences to extract rules and tools for predicting aircraft damage likely to be incurred during combat and also designing and testing aircrafts to survive the hazards of performing military missions.

Some examples of Mr. Lentz's many contributions are described below.

In the early 1970's, he devised and conducted the first-ever digital-based vulnerability analysis of Army and Air Force helicopters assigned to high-risk missions. This included the first-ever use of graphic codes for meaningful interpretation of results. By the late 1970's, he had advanced and applied his digital analysis techniques to evaluate mission vulnerability risks for combat aircraft and to evaluate design modifications necessary to achieve desired combat damage tolerance capabilities. (F-15, F-16, A-10, B-1, B-2, and C-130). His analytical skills and tools were instrumental in selecting the preferred cruise missile design for the USN and USAF; deleting the cost and weight of a high-tech fuel-vapor explosion protection system for the B-1 aircraft; and establishing baseline performance requirements for evaluating next-generation computational engineering workstations being developed for the USAF and DoD.

The 1980's saw Mr. Lentz continue to lead the development and application of analytical codes and high speed computing capabilities to predict the combat vulnerability of weapon systems including F-16, F-15, F-22, F-35, C-5, C-17, and B-2. He developed the first multi-station computer network at WPAFB and provided technical support for four years prior to base-wide implementation of such capability. His vulnerability analysis codes became a well-recognized benchmark capability in his role as Air Force representative to DoD in its development of engineering work station computers. He led the transformation of these vulnerability analysis codes into a standardized process still used by all military services and industry. He was a key member of the teams developing survivability requirements for the H-60 Blackhawk helicopter and the V-22 Osprey Tiltroter Aircraft and personally led an independent analysis of the vulnerability of the Boeing 747 variant that is now known as Air Force One.

In the 1990's, Mr. Lentz shifted focus of his talent from predicting vulnerability to reducing vulnerability. He formed and directed a Tri-Service program to select an environmentally friendly chemical agent for aircraft on-board fire suppressions systems. The agents are now widely used in lieu of environmentally hazardous Halon and the guidelines used to size and evaluate alternative systems are still in use. To facilitate this agent evaluation process, he directed the revitalization and upgrade of a 1960's vintage engine nacelle simulator to serve as a test and evaluation (T&E) facility now being used by world-class researchers to understand and evaluate the dynamics of engine-bay fire suppression, and doing this without the cost and risk of using actual aircraft engines and structures. Ever-focused on the warfighter he implemented a program for conversion of these findings into design tools that are now used throughout DoD for predicting the probability of on-board fires in air, land, and water vehicles exposed to combat. His background in fire/explosion prevention was called on when he served as a Senior Air Force Technical Advisor for the FAA investigation of the TWA aircraft mid-air explosion. His understanding of conditions necessary for such an explosion led to replicating the damage conditions and devising prevention techniques. In addition, he also led a joint FAA-USAF-Industry effort to establish design and test criteria for prevention and tolerance of bomb-blast effects. He was selected to run the DoD Survivability/Vulnerability (S/V) Information Analysis Center which is a $100+M

*Lentz retirement continued on page 9*

# IAC Spotlight: CBRNIAC

The Chemical, Biological, Radiological, and Nuclear Defense Information Analysis Center (CBRNIAC) is operated by Battelle Memorial Institute under contract to the Defense Director of Defense Research and Engineering (DDR&E), Defense Technical Information Center (DTIC), Information Analysis Center (IAC) Program. IACs are chartered by DoD to provide support in key technology areas such as chemical and biological defense, survivability and vulnerability, reliability, advanced materials, sensors, information assurance, weapons systems, software, and chemical propulsion. The CBRNIAC, one of these IACs, is a full service Department of Defense (DoD) Information Analysis Center. Established in 1986 and located on the Edgewood Area of Aberdeen Proving Ground, Maryland, the CBRNIAC serves as DoD's centralized source for Chemical and Biological Defense (CBD) information and technology. CBRNIAC's services and support are also available to all Federal Government agencies in addition to the DoD, their contractors, and state and local government entities, to include first responders.

The technical scope of the CBRNIAC is extremely broad and encompasses all aspects of weapons of mass destruction defense for both DoD and Homeland Security applications. This technical scope includes: Analysis of Manufacturing Processes for NBC Defense Systems, Chemical and Physical Properties of CBD Materials, Chemical and Biological Identification, Combat Effectiveness, Counter Proliferation, Counter Terrorism, Decontamination, Defense Conversion and Dual-Use Technology Transfer, Demilitarization, Domestic Preparedness, Environmental Fate and Effects, Force Protection, Individual and Collective Protection, International Technology Proliferation and Arms Control, Medical Effects and Treatment, Nuclear, Biological and Chemical Survivability, Radiological and Nuclear Defense, Smoke and Obscurants, Toxic Industrial Chemicals/Toxic Industrial Materials, Toxicology, Treaty Verification and Compliance, and Warning and Identification.

The CBRNIAC has two distinct components available to support its users: the Core Program and the Technical Area Task (TAT) Program. Under the Core Program, the CBRNIAC is resourced by DTIC to acquire, process, generate, analyze, and disseminate chemical, biological, radiological, and nuclear (CBRN) Defense and Homeland Security information to the DoD, other Government agencies, DoD and Government contractors, state and local governments, and first responders. In essence, the CBRNIAC Core Program is an already funded resource to assist you in dealing with and understanding CBRN defense and Homeland Security technologies and their applications.

The principal CBRNIAC Core Program services include a range of no cost support, such as responses to technical inquiries in any of our scope areas, newsletter subscriptions, database accounts through our web site, regular email updates, and an extensive web site, along with product sales. Although limited to 4 hours of analyst time per inquiry, the CBRNIAC inquiry program is one of our premier no-cost services, since the CBRNIAC excels at locating and analyzing information within its extensive technical scope. The inquiry program responds to approximately 900 inquiries each year and usage is evenly split between Government agencies and their supporting contractors. The CBRNIAC has responded to aircraft CB survivability inquiries from DoD and non-DoD Federal Agencies, the military services and supporting industry. Newsletter subscriptions are provided to all members of the CBRN Defense and Homeland Security communities at no charge, although approximately 2/3rds of the subscribers are with Government agencies. The CBRNIAC newsletters also offer a vehicle to inform others of your activities in relevant areas. Database accounts through our web site make it possible for authorized users from both Government and supporting contractors to perform their own bibliographic searches. Roughly 2/3rds of these database accounts are held by Government personnel, with the rest used by supporting contractors. In most cases, these users will need to work through our inquiry service to obtain the actual documents or detailed information from identified documents of interest from their search results. The email updates provided to Government and contractors in roughly equal numbers address recent CBRNIAC activities and are provided to those we serve at no cost. The content on the CBRNIAC website, except for our database, is available to all site visitors. The CBRNIAC Core Program also maintains a centralized repository of CBRN defense and Homeland Security scientific and technical information. This repository contains approximately 125,000 database records and over 100,000 document holdings, most in electronic format. The CBRNIAC welcomes contributions to this repository, and would be happy to work with you on the details. CBRNIAC product sales are limited to requesters who meet the requirements of the distribution statement for each item in our catalog. If you need to manage release of a restricted distribution item, you may want to consider working through our product sales program, since the CBRNIAC will perform that function at no cost to the contributing agency.

As part of its Core Program, the CBRNIAC has focused on CB survivability of materials and systems, including those associated with aircraft. In addition to inquiry support in this area, the CBRNIAC maintains the Chemical Defense Materials Database, offers the Chemical Defense Materials Databook and the Susceptibility of Aircraft Materials to Chemical Warfare Agents handbook through its product program, and is actively involved in a DoD level steering committee overseeing implementation of an updated chemical and biological contamination survivability database.

The CBRNIAC's TAT Program is a pre-competed task-order contract vehicle that enables us to support efforts beyond the levels available through Core Program services. TATs cover information collection; databases; modeling and simulation; studies and analyses; basic and applied research and development (including laboratory, surety agent, and pathogen work); test and evaluation; technical consulting; training; conferences; testing of components, systems, and subsystems; engineering design, prototyping, and low-rate production in any of our scope areas. Knowledge management and development services are also available through the TAT program. The TAT Program is used most extensively by both DoD and other Federal Government agencies, and also provides support to Government contractors. CBRNIAC TATs depend heavily on the information contained in the Core Program repository and all information produced through TATs is incorporated into the CBRNIAC repository, where it is used, consistent with distribution restrictions, to support future TAT efforts and to aid in preparing inquiry responses.

The CBRNIAC's Core Program provides CBRN defense and Homeland Security services at little or no cost to authorized requesters from throughout the CBRN and Homeland Security communities, while the TAT program offers a competitively awarded, quick, convenient and responsive contract mechanism to support larger scale technical efforts that fall within our scope. To find out more about the CBRNIAC, visit the CBRNIAC's web site at www.cbrniac.apgea.army.mil or contact the CBRNIAC, (410) 676-9030, Email: cbrniac@battelle.org

*Dr. James King is Deputy Director of the Chemical CBRNIAC. He has over 29 years of research and development experience, including 22 years of active duty military service, at levels ranging from research scientist to senior program administrator, with over 19 years of that experience in CBRN defense.*

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*Lentz retirement continued from page 7*

library for archiving, retrieving, and analyzing combat system S/V performance. During Desert Storm, he served as a USAF technical advisor for forensic analysis to identify enemy weapons that were causing combat damage. His techniques and results are still in use in-theater today.

The 2000's saw Mr. Lentz continue to apply his understanding of fuel fire/explosion. He led a congressionally mandated effort to quickly explore a technique using metal mesh to prevent fuel tank vapor explosion. This included development of a new facility for ground based simulation of fuel tank temperatures, vibrations, oscillations, and pressures as seen in flight. This ability to evaluate fuel tank hazardous flight situations under controlled conditions is a first for the T&E community. He teamed with NASA to conduct the first-ever evaluation of weapons likely to be encountered as threats to commercial aircraft. He also was selected as the Air Force representative for a DoD initiative to evaluate combat survivability effects of the next generation of aircraft fuels. This work included development of a new handbook for use by industry and each DoD Service in their own efforts to understand and exploit new fuels. For his contribution to this effort he received the prestigious Exemplary Civilian Service Award – quite an honor! Not willing to coast into retirement, he has lead an initiative which will bring on-line in 2008 a new $2M facility for Tri-Service use in accelerating the definition and evaluation of survivability related issues for these new fuels.

Mr. Lentz has been a vital member of all teams he has worked with and has contributed immeasurably to the proven survival characteristics of USAF weapon systems including: A-10, F-15, F-16, F-22, F-35, B-1, B-2, C-5, C-130, and C-17. Mr. Lentz has unselfishly devoted his technical talents to the pursuit of science that enhances warfighter mission survival. His success in pushing back the boundaries of the unknown has truly elevated the science and the art of increasing aircraft mission survival in a hazardous environment.

Mr. Lentz's outstanding contributions represent a stellar career in the federal civil service and a monumental contribution to the USAF. His distinctive accomplishments and dedication are most deserving of recognition upon culmination of an exemplary career. The only thing left to say is "Thanks Marty – for a job well done".

# NanoMist® Ultra Fine Fog Fire Protection and Advanced Inerting Technologies

*by Dr. K.C.Adiga and Dr. J. Michael Bennett*

A breakthrough has recently been achieved in the development of a fire and explosion protection technology that meets the environmental, operational and performance requirements for many applications. It has been found to be an ideal approach for many commercial fire extinguishing applications, as well as weapons systems such as U.S. Navy shipboard electronics space applications. It appears to have potential to meet the needs of aircraft survivability and safety objectives in both fire extinguishing, securing by reflash/re-ignition prevention, and fuel tank inerting system configurations.

Various fire and explosion protection government agencies and end user groups from various industries and communities have evolved strong preferences for "natural" water, or inert gas-based solutions for their various applications to replace their current use of Halon chemicals. There are several reasons for this:

(1) international end users must comply with much more severe regulations, including global warming, atmospheric lifetime constraints, and ozone depletion, which largely limit alternatives to the aforementioned,

(2) hydrogen fluoride production due to decomposition of the common gaseous Halon alternatives in flames or hot regions pose significant corrosive or health concerns to occupants, and

(3) the performance of the gaseous fluorocarbon-based Halon alternatives found over the years has still resulted in performance levels that require 2-3 times or more capacity compared to Halon for equivalent protection, which is unacceptable for many weight and space critical applications such as weapons platforms. The "natural" alternatives such as water have some design challenges that have limited their implementation so far, including the following:

(1) regular water mist systems with large droplets have difficulty in flowing through cluttered areas, around corners and behind obstructions like a gas,

(2) these inefficiencies result in systems that are often too big and heavy even if they work satisfactorily, and

(3) other operational and environmental limitations of water for some applications must be addressed. This new technology breakthrough addresses these concerns in a manner suitable for some aircraft applications.

## The Technology

NanoMist® is a proprietary ambient pressure ultra fine water fog technology that produces extremely fine fog (below 10 micron) and has very different physical traits than conventional water mist systems, without the use of pressure systems or nozzles. As a result, the NanoMist ultra fine water fog thus created is a unique physical state, exhibiting dramatic enhancements in its desirable properties as a pseudo gas over traditional misting techniques. This is resulting now in a real "paradigm shift" in future fire protection technology and the range of applications that can effectively use water as a permanent solution. Over the past half a decade, extensive research and technology evaluation efforts at the NanoMist Systems laboratory and at other independent research organizations revealed that ultrafine water fog with droplet sizes below 10 microns shows transport behavior similar to clean gaseous agents. The gas-like fog is considered as a "microfluid", based on the dispersion of nearly micron sized droplets in a gaseous medium. The measured mass concentration of NanoMist-like fog by the U.S. Navy Research Laboratory for the extinguishment of fires is the lowest (~0.2 kg /m3) compared to all gaseous agents, including Halon 1301! Using the extreme heat extraction capability of water fog and the near-instantaneous rate of droplet evaporation possible in the fog state, massive amounts of heat energy can be extracted quickly from the fire or explosion zone, thereby explaining its efficiency. As an example, NanoMist has been shown to extinguish large cooking oil fires within 5 seconds using as little as 100 ml of water. Thus, NanoMist fire protection technology may have a considerable impact on future commercial and military fire protection applications.

A photograph of a NanoMist generator demonstration unit, discharging a continuous flow of water fog, is shown in Figure 1. This prototype unit, built using off-the-shelf electronics, mechanical and other electrical components, is envisioned to be further optimized soon into a unit no bigger than 6 inches in diameter by six inches tall, using devices and components already available for exploitation in the marketplace, or with limited customization. Higher flow capacity units are also in development that will greatly expand the coverage area per unit, and the rate at which the fog can quickly fill a large area.

Unlike chemical agents, NanoMist is safe and economical to deploy preemptively, to prevent ignition from occurring, or can be deployed after a fire has been knocked down by another agent to prevent re-ignition for extended periods.


Figure 1: Prototype of NanoMist® Atomization Device

NanoMist can "hang" intact above a fuel spill or hot fuel for a significant amount of time, even without replenishment. Because of its fine droplet size and resultant rapid evaporation, the mist does not really wet surrounding surfaces, thereby negating the deleterious effects of inadvertent discharges. The electronics exposure test by the Navy did not show a significant impact on the ability of the electronics when installed in a manner consistent with industry practice, to continue operating during exposure (Forssell, E.W., Scheffey, J.L., DiNenno, P.J., Back, III, G.G., Hatcher, Jr, R.F., Adiga, K.C., Farley, J.P., and Williams, F.W., "Scaled-up False Deck Development Testing of NanoMist Water Mist Fire Suppression Systems," NRL Ltr Rpt Ser 6180/0312, Naval Research Laboratory, Washington, DC, July 27, 2005). Its ability to flow like a gas to penetrate tightly bundled pipes, and around corners multiple times to fill complex compartments has been shown by the Navy tests. Its ability to be transported through small ductwork up to one hundred feet in length has been shown recently; all these behaviors are unheard of by other liquid-based extinguishants.

## Aviation Safety and Survivability Applications

NanoMist devices have been demonstrated generating fogs of jet fuel to create fuel-rich conditions within the ullage of a fuel tank to inert against explosions. This concept of inerting or quenching by use of fuel was used in actual fielded military aircraft in the 1950s by injecting pentane fuel onto fuel tank explosions as they were occurring, and were understood then to be a weight efficient means of explosion suppression; only the limitations of fast response detection at the time limited its proliferation to other platforms. Published research conducted decades ago by McDonnell Douglas found that the concept of pre-inerting an ullage by spraying it with a fuel mist was an effective means of inerting (Wiggin, E.W., and Malmberg, Q.C., "Aircraft Fuel Tank Inerting by Means of Fuel Cell Fogging", McDonnell Douglas Company, AFAPL-TR-69-46, Air Force Propulsion Laboratory, May 1969). However, their protection regime was only observed over a limited temperature range due to the limits of high-pressure nozzles that could achieve only a 13% weight of fuel in air, rather than the 22% required for all conditions. Notably, NanoMist can provide over 30% by weight of fuel in air, which is too rich to ignite thereby is more than adequate for the task. Figure 2 shows that a kerosene fuel fog can create opaque, well mixed fog conditions that can reside for extended periods, whether or not the fog is replenished. This simple system (using fuel or other inertants), which can be mounted adjacent to or in a fuel tank, is a low cost, weight and easy-to-retrofit option with many advantages over OBIGGS, and may also be more practical for applications like UAVs and small aircraft.


Figure 2: Lab tank filled with ultra fine kerosene fog

Such systems can also protect cargo or large dry bays, either as a stand-alone system or providing sustained re-ignition protection after initial fire knockdown from a fast-response system. It can also provide crew protection in a safe manner against fire events.

The NanoMist Company is currently seeking airframers or other development partners to fully exploit this technology for aircraft safety and survivability uses, and will be soon demonstrating its capabilities in full scale tests conducted by the Federal Aviation Administration.

*Dr. Adiga is the founder and CEO of NanoMist systems, LLC. His Ph.D. was in the area of solid rocket fuel combustion. Dr. Adiga has 25 years of academic and industrial experience in fire protection science, combustion, explosion, and CFD modeling. Dr. Adiga has 26 patents (issued and pending). He has collaborated with the U.S. Naval Research Laboratory on ultra-fine water mist work for the past 4 years. His current thrust is on establishing the science and technology of nearly micron-sized water fog as a fire suppression and advanced inerting system.*

*J. Michael Bennett, Ph.D is the President of Bennettech, LLC, specializing in the development of fire and explosion technologies. He served as the Team Leader of the Aircraft Fire Protection Technology Team at the Survivability and Safety Flight at Wright-Patterson AFB for sixteen years, and as Technical Director of the National Halon Replacement Program for Aviation.*

# Model Spotlight: Vulnerability Toolkit

The latest release of the SURVIAC Vulnerability Toolkit includes updates to the Fast Shotline Generator (FASTGEN), Computation of Vulnerable Area Tool (COVART), and the Combat Assessment Tool (CAT). This release also includes updates to several geometry viewers and utilities.

FASTGEN 5.5: The Fast Shotline Generator (FASTGEN) traces the path of a threat's shotline through a target, which is composed of a three-dimensional database of objects called components. The set of components encountered along a shotline is arranged in the order of encounter which called a line of sight (LOS). This LOS data can be used as input to vulnerability assessment models such as COVART.

FASTGEN is capable of processing kinetic energy (KE) threats such as single fragments and projectiles, as well as high-explosive (HE) threats including MANPADS and HEIs. KE threats can be processed as single shotlines, groups of shotlines (multi-hit) or a grid of shotlines across the target. HE threats can be processed as single impacts, proximity bursts, or a grid of shotlines across the target. FASTGEN is written in FORTRAN90 and supported on PCs running Windows or Linux, and UNIX platforms running Sun Solaris and SGI Irix operating systems.

Major improvements incorporated in this release include support for multi-hit assessments and enhanced support for the Combat Assessment Tool (CAT). The multi-hit capability allows users to assess bullet and fragment threats as a group of impacts, as could be seen from a burst of gun fire. This data is passed to COVART for analysis, taking into account multiply vulnerable failures due to the multiple impacts. CAT support includes the ability to provide data to COVART for computation of penetration information for use with CAT. Minor bug fixes are also included in this release. The FASTGEN Users manual has also been updated to reflect the new features implemented in this release, and corrects several errors present in previous versions of the documentation.

COVART 5.1: The Computation of Vulnerable ARea Tool (COVART) computer program is a method for determining the vulnerable areas of targets damaged by impacting single kinetic-energy (KE) penetrators, or high-explosive (HE) rounds. Primary emphasis is given to aerial targets, both fixed and rotary wing; however, vulnerable areas of ground targets can also be determined, provided that their damage definitions and material properties are consistent with those acceptable to COVART 5.1. COVART 5.1 is a modularized version of COVART and contains separate modules for penetration equations (JTCG projectiles, JTCG fragments and FATEPEN 2.5), damage (Pcd|h), and fault trees (MV). COVART is written in FORTRAN77 and supported on PCs running Windows or Linux, and UNIX platforms running Sun Solaris and SGI Irix operating systems.

COVART 5.1 contains, in addition to the features in COVART 5.0, the following new features: Multi-hit capability, and support for the Combat Assessment Tool (CAT). This release also includes many significant changes as a result of the COVART Critical Repairs project, which addressed several major Software Change Requests (SCRs). The COVART Users manual has also been updated to reflect the new features implemented in this release.

Combat Assessment Tool (CAT) 3.0: The Combat Assessment Tool (CAT) 3.0 is an interactive tool for visualizing potential impact locations and damage (holes) from high-explosive (HE) and kinetic energy (KE) threats. This tool has been used previously by the Joint Combat Assessment Team (JCAT) for assisting in identification of threat and visualization of encounter conditions. Other potential uses include aiding in ballistic test planning and documentation and visualization in support of vulnerability analysis.

The user selects a target model and threat file of interest and then interactively places the threat relative to the target in the viewer. Threat selection and placement is based on combat debriefing information or upon test conditions and parameters. After target/threat orientation data is input, FASTGEN and COVART are run from the viewer to compute and display threat damage patterns on the target surface. This process can be repeated by varying threat parameters until a suitable match is obtained between modeled damage patterns and damage patterns observed in the field, or until results match desired test conditions and results.

CAT 3.0 is supported only on PCs running Microsoft Windows.

For more information on obtaining the Vulnerability Toolkit, please contact Mr. A. J. Brown, SURVIAC, (937) 255-3828 x284. Email: brown_aj@bah.com.

# SURVIAC and partners act quickly to improve troop safety

The Fox M93A1 Nuclear, Biological, and Chemical Reconnaissance System (NBCRS) is a mobile laboratory that takes air and ground samples and immediately analyzes them for signs of weapons of mass destruction. The mission of the wheeled NBCRS is to detect, identify, mark, sample, and report chemical and radiological contamination on the battlefield. The Fox improves the survivability and mobility of U.S. ground forces by providing increased situational awareness and information superiority to headquarters and combat maneuver elements. With the ability to provide rapid, accurate chemical and radiological contamination information to these elements, the NBCRS vehicle forms a key portion of the full-dimensional protection concept.

Fox M93A1P1 Survivability Vehicle

Soldiers on the front lines are safer now thanks to the cooperative efforts of U.S. Army Government civilian and ontractor personnel based at Aberdeen Proving Ground, Maryland. In response to a request from the field, the Aberdeen-based personnel made a significant contribution to improve safety and operational capabilities of the warfighter through armor enhancements to the Fox M93A1, resulting in the Fox M93A1P1 Survivability vehicle. The expertise of the SURVIAC personnel was fundamental to the success of the program. In just 2 ½ years, the support team successfully designed, tested, trained personnel, and fielded the improved equipment to Central Command (CENTCOM) in support of Operation Iraqi Freedom. To add to the success, forward-deployed soldiers have already noted the benefits of the upgraded vehicle in their missions.

Soldiers in Camp Anaconda, Iraq receive the survivabilty upgraded Fox M93A1P1 vehicle.

## The call for assistance

In June 2004, the Joint Project Manager for Nuclear Biological Chemical Contamination Avoidance (JPM NBC CA) received an Operational Need Statement (ONS) from the field requesting various upgrades to the existing Fox M93A1 vehicles in Iraq. Survivability upgrades allow the crew to better withstand hostile threats, consisting of Improvised Explosive Devices (IEDs) and Rocket Propelled Grenades (RPGs), without suffering an abortive impairment of its ability to accomplish its designated mission, as well as adding additional firepower. These upgrades include improvements in IED protection (plate armor) and protection against RPGs (Slat armor). Slat armor has already proved to be quite successful with other vehicles in Iraq in defeating attacks from RPGs. In addition to the IED and Slat armor protection, the Common Remotely Operated Weapon Station (CROWS), consisting of an upgrade from an M240B, 7.62mm machine gun, to a .50 cal machine gun, was also installed. The CROWS provides the M93A1P1 the capability to remotely operate crew served weapons and improves system accuracy and operational response time by integrating state of the art drives, controls and sensors. The system upgrades to the M93A1 Fox Vehicle created the M93A1P1 Fox Survivability Vehicle.

## Taking action - Testing and Fielding

The Operational Need Statement call for assistance initiated a series of actions from the Joint Project Manager for Nuclear Biological Chemical Contamination Avoidance (JPM NBC CA), SURVIAC and General Dynamics Land Systems (GDLS). The cooperative effort between JPM NBC CA, GDLS and SURVIAC resulted in a 2 ½ year turnaround of the M93A1P1 Fox Survivability Vehicle, from design through implementation and subsequent fielding. The tailored acquisition process began with a prototype design followed by focused testing and revision of technical manual documentation. It culminated in coordination with multiple troop units at numerous locations to meet fluid deployment timelines.

As the welfare of the soldier is of paramount concern, development and test agencies documented various safety assessments and confirmations during the testing of the upgraded systems. This documentation included: the Developmental Test Command Safety Confirmation, U.S. Army Tank-automotive and Armaments Command Safety Assessment, and an engineering analysis conducted by Edgewood Chemical Biological Center. For more information on these reports, please contact Mr. David Rickard, (410) 436-3888, rickard_david@bah.com.

# Joint Critical Infrastructure Conference Held


Photo by Keith Weller, ARS/USDA

A Joint Critical Infrastructure Conference was held at the University of Cincinnati. This conference was an educational initiative to define, national, state, and local roles and responsibilities in protecting critical infrastructure. Protecting the national infrastructure and implementing the National Infrastructure Protection Plan is one of the seven national priorities of the National Preparedness Goal. This conference was the first in a series of conferences that will address the critical infrastructure topic. The focus of this first conference was agro-terrorism. Speakers came from a broad range of government organizations, including DHS, FBI, Ohio Department of Health, Ohio Homeland Security (OHS), and Hamilton County Emergency Management Agency (EMA). Speakers presented the roles that all the various levels of government played in critical infrastructure protection.

A number of critical infrastructure data bases were also presented. The National Asset Data Base was developed by the DHS and is a repository and inventory for all of the national infrastructure and resources. The data base provides a foundation for strategic risk analysis and facilitates resource allocation, programmatic planning based on risk levels.

The Homeland Security Information Network – Critical Infrastructure (HSIN-CI) was also discussed. HSIN-CI Pilot is an unclassified network and governance program providing a nation-wide platform that enables the sharing of essential homeland security information with the proper stakeholders. This information sharing is accomplished both horizontally across the government and vertically among federal, state and local governments, private sector and citizens as outlined in the President's National Strategy for Homeland Security.


Photo by Keith Weller, ARS/USDA

HSIN-CI significantly increases the exchange of unclassified information to critical infrastructure owners and operators and the private sector.

HSIN-CI is locally governed and administered by subject matter experts and decision makers from both the private and public sector with the support of Federal Regional Coordinators.

HSIN-CI provides a tangible tool to engage the community in homeland security by supporting locally relevant information sharing with a direct pipeline to and from the federal government.

HSIN-CI delivers information sharing, alert notification services to the right people - those that need to know, and those that need to act.

Conference attendees were also briefed on the OHS Strategic Analysis & Information Center. The center, while operated under the OHS division, is actually grouping of local, county, state, federal, and private sector agencies working as a team to collect, analyze, and disseminate terrorism related intelligence. The mission of the center is to gather data on individual events that occur across the state, analyze these events in the context of a broader strategic picture using the latest federal intelligence updates, and determine if the events were random events or a coordinated terrorist attack.


Photo by Bruce Fritz, ARS/USDA

The final conference event consisted of a panel discussion of what the various organizations' responses would be in the event of a critical incident. The critical incident discussed was an agricultural attack and included the various response levels within the state, as well as the supporting federal agencies.

*For more information on this conference, please contact Mr. Matt Kolleck, SURVIAC, (937) 255-3828 x280, E-mail: kolleck_matt@bah.com*

# Calendar of Events

## Sep 2008

### Weaponeering: Conventional Weapon System Effectiveness
**Sep 09, 2008 - Sep 11, 2008**
POC: Morris Driels, (831) 656-3383
E-mail: morris@nps.navy.mil
http://www.weaponeering.com

### MODSIM World Conference 2008
**Sep 16, 2008 - Sep 18, 2008**
Virginia Beach, VA
POC: Mike Robinson
E-mail: rmrobins@odu.edu
http://www.modsimworld2007.com

### 2008 Joint Aircraft Survivability Program Review
**Sep 16, 2008 - Sep 18, 2008**
Nellis AFB, NV
POC: Darnell Marbury, (703) 604-0817
E-mail: darnell.marbury@navy.mil
Conference Code: JOI63396
https://www.enstg.com/invitation

### Vehicle Survivability Summit 2008: "Increasing Armour Strength and Reducing the IED Threat in Combat Theatres"
**Sep 22, 2008 - Sep 24, 2008**
Berlin, Germany
POC: Malin Petterson
+44 (0) 20 7202 7700
E-mail:Malin.Petterson@wtgevents.com
http://www.vssummit.com/

### 2008 Joint Undersea Warfare Technology Fall Conference
**Sep 29, 2008 - Oct 02, 2008**
Groton, CT
POC: NDIA, Kimberly Williams
(703) 247-2578
E-mail: kwilliams@ndia.org
http://www.ndia.org

## Oct 2008

### Command Control Communications Computers and Intelligence Technology (C4IST)
**Oct 07, 2008 - Oct 09, 2008**
Ft. Huachuca, AZ
POC: AFCEA Southern Arizona Chapter
http://www.afceac4ist.com

### 46th Annual Targets, UAVs & Range Operations Symposium & Exhibition: "Supporting the Warfighter in Times of Change"
**Oct 08, 2008 - Oct 10, 2008**
San Antonio, TX
POC: NDIA, Meredith Geary, (703) 247-9476
E-mail: mgeary@ndia.org
http://www.ndia.org

### 2008 Combat Vehicles Conference
**Oct 20, 2008 - Oct 22, 2008**
Dearborn, MI
POC: NDIA, Kimberly Williams
(703) 247-2578
E-mail: kwilliams@ndia.org
http://www.ndia.org

### 2008 ESRI Homeland Security GIS Summit (HSSummit)
**Oct 20, 2008 - Oct 23, 2008**
Scottsdale, AZ
POC: ESRI, KC Shearer
(909) 793-2853 x1-2894
E-mail: hssummit@esri.com
http://www.esri.com/events/homeland/index.html

### Aircraft Fire Protection and Mishap Investigation Course
**Oct 27, 2008 - Oct 31, 2008**
Miamisburg, OH
POC: AFP Associates, Robert Clodfelter
(937) 435-8778
E-mail: afp1fire@aol.com
http://www.afp1fire.com/course.htm

### National Homeland Defense Foundation Symposium VI
**Oct 28, 2008 - Oct 30, 2008**
Colorado Springs, CO
POC: Anne Marshal, (719) 577-9016
E-mail: amarshall@isiscompany.net
http://www.nhdf.org

### Precision Strike Technology Symposium
**Oct 28, 2008 - Oct 30, 2008**
Laurel, MD
Precision Strike Association, Dawn Campbell
(703) 247-2590
E-mail: info@precisionstrike.org
http://www.precisionstrike.org/techsym.htm

## Nov 2008

### NDIA Aircraft Survivability 2008: "Low Altitude Today, Preparing for Tomorrow"
**Nov 04, 2008 - Nov 07, 2008**
POC: NDIA, Meredith Geary, (703) 247-9476
E-mail: mgeary@ndia.org
http://www.ndia.org

### MILCOM 2008
**Nov 16, 2008 - Oct 19, 2008**
San Diego, CA
POC: AFCEA
http://www.afcea.org

### Aircraft Fire and Explosion: Prevention and Survivability in Accidents, Combat and Terrorist Attacks
**Nov 18, 2008 - Nov 21, 2008**
Greater Boston Area, MA
POC: BlazeTech Corp, Dr. Albert Moussa
(617) 661-0700
E-mail: amoussa@blazetech.com
http://www.blazetech.com/firecourse.html

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